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(71) Applicant (*for all designated States except US*): ELECTRONICS AND TELECOMMUNICATIONS RESEARCH INSTITUTE [KR/KR]; 161 Gajeong-dong, Yuseong-gu, Daejeon 305-350 (KR).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): HAN, Kyu Seo [KR/KR]; Chungsol Apt. 103-1010, Songgang-dong,, Yuseong-gu, Daejeon 305-752 (KR). CHUN, Byung Tae [KR/KR]; Hanwoori Apt. 107-703, Tanbang-dong,, Seo-gu, Daejeon 302-768 (KR). LEE, Jae Yeon [KR/KR]; Hanvit Apt. 131-1501, Eoeun-dong,, Yuseong-gu, Daejeon 305-755 (KR). CHUNG, Yun Koo [KR/KR]; Dasol Apt. 102-506, Gung-dong,, Yuseong-gu, Daejeon 305-335 (KR). AHN, Chieteuk [KR/KR]; Expo Apt. 208-603, Jeonmin-dong,, Yuseong-gu, Daejeon 305-761 (KR).

(74) Agent: JANG, Seong Ku; 17th Fl., KEC Building, 275-7, Yangjae-dong, Seocho-ku, Seoul 137-130 (KR).

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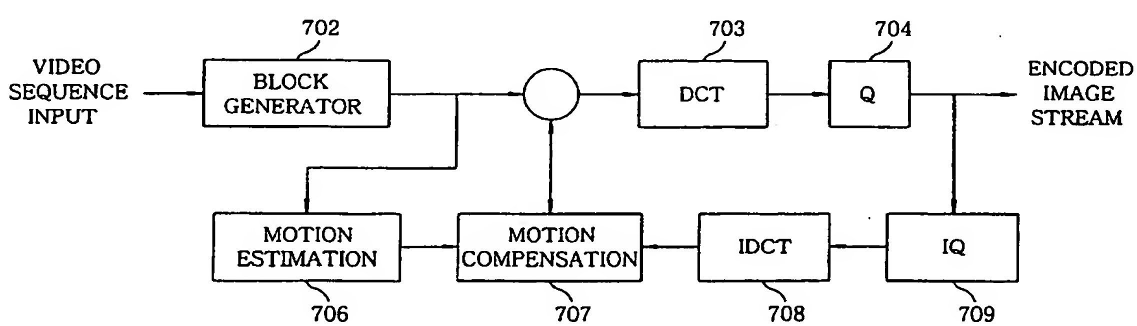
(54) Title: METHOD AND APPARATUS FOR MOTION ESTIMATION USING ADAPTIVE SEARCH PATTERN FOR VIDEO SEQUENCE COMPRESSION



(57) Abstract: In a method for motion estimation using adaptive patterns in a video sequence compression system, an initial search pattern located at a center of a search window in a block of a video frame is determined. A location of a minimum block distortion measure (BDM) is searched in the initial search pattern. A horizontal search pattern for functioning on the search window is determined in the horizontal direction to search a location of a minimum BDM in the horizontal search pattern. A vertical search pattern for operating on the search window is determined in the vertical direction to search a location of a minimum BDM in the vertical search pattern. The location of the minimum BDM in each pattern is designated to be a motion vector. A search pattern to be used in a subsequent searching stage is determined based on the location of the minimum BDM in each pattern.

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METHOD AND APPARATUS FOR MOTION ESTIMATION USING ADAPTIVE SEARCH PATTERN FOR VIDEO SEQUENCE COMPRESSION

FIELD OF THE INVENTION

The present invention relates to a video sequence compression technique; and, more particularly, to a method and apparatus for motion estimation using adaptive search patterns for a video sequence compression, which is suitable for providing a better motion estimation precision and a higher computational efficiency in a motion compensation technique among compression technologies using a correlation between video frames.

BACKGROUND OF THE INVENTION

A motion compensation compression technique refers to a technology for removing a temporal redundancy between successive video frames by using a motion estimation technique. A block-based motion estimation technique has been adopted in a compression standard of a video sequence such as MPEG-4, H.263 and the like.

The block-based motion estimation technique is widely used even in case of another compression standard due to its facility of implementation in hardware and/or software.

In the block-based motion estimation technique, each video frame is divided into a plurality of blocks, wherein each of the blocks is associated with a motion vector to describe a location change between a block in a reference video frame and that of a current video frame corresponding to the block in the reference video frame. The motion vector can be obtained from the location change of most similar blocks in the two frames. In other words, based on a block distortion measure (BDM) for calculating similarity between blocks, a block having a minimum BDM value is selected.

However, a currently used block-based motion estimation technique is considered to require a great amount of computation and much time therefor. To be specific, a full search motion estimation regarded to be comparatively accurate calculates a mean absolute deviation for every block in a search window of a predetermined size and selects a block having a minimum value thereof to thereby obtain a motion vector. In this case, a computational amount for the motion vector occupies more than 70% of that for an entire video compression.

To that end, a plurality of fast block-based motion estimation techniques have been suggested. However, such techniques are sub-optimal and do not provide as high of accuracy as the full search motion estimation technique because of an error caused by an assumption for applying an estimation method.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a motion estimation method and apparatus using adaptive search patterns of a video sequence compression system, which is computationally efficient and improves the accuracy of the full search motion estimation, wherein a search pattern is determined based on a result of a previous search process and a horizontal and a vertical search pattern are adaptively determined in each stage of the search process.

In accordance with one aspect of the invention, there is provided a method for motion estimation using adaptive patterns in a video sequence compression system, including the steps of: (a) determining an initial search pattern located at a center of a search window in a block of a video frame; (b) searching a location of a minimum block distortion measure (BDM) in the initial search pattern; (c) determining a horizontal search pattern for functioning on

the search window in the horizontal direction to search a location of a minimum BDM in the horizontal search pattern; (d) determining a vertical search pattern for operating on the search window in the vertical direction to search a location of a minimum BDM in the vertical search pattern; (e) designating the location of the minimum BDM in the initial search pattern to be a motion vector; (f) designating the location of the minimum BDM in the horizontal search pattern to be a motion vector; (g) designating the location of the minimum BDM in the vertical search pattern to be a motion vector; (h) determining a search pattern to be used in a subsequent searching stage based on the location of the minimum BDM in the initial search pattern; (i) determining a search pattern to be used in a subsequent searching stage based on the location of the minimum BDM in the horizontal search pattern; and (j) determining a search pattern to be used in a subsequent searching stage based on the location of the minimum BDM in the vertical search pattern.

In accordance with another aspect of the invention, there is provided an apparatus for motion estimation using adaptive search patterns for a video sequence compression, including; a current image block generation means for generating a current image block; a previous image block generation means for generating a previous image block; a first and a second memory for storing image blocks generated by the current image block generation means and the previous image block generation means; and a pattern determination and motion estimation means for retrieving data of image block stored in the first and the second memory to search a location of a minimum BDM in a current search pattern of the data of the retrieved image block and determining a next search pattern to be used in a subsequent searching stage depending on the location of the minimum BDM.

BRIEF DESCRIPTION OF THE INVENTION

The above and other objects and features of the present invention will become apparent from the following description of preferred embodiments, given in conjunction with the accompanying drawings, in which:

Fig. 1 shows an exemplary diagram of an initial search pattern employed in the present invention;

Fig. 2 illustrates an exemplary diagram of a horizontal search pattern employed in the present invention;

Fig. 3 provides an exemplary diagram of a vertical search pattern employed in the present invention;

Figs. 4A and 4B present examples of search determination patterns on a location basis in the horizontal search pattern employed in the present invention;

Figs. 5A and 5B represent examples of search determination patterns on a location basis in the vertical search pattern employed in the present invention;

Fig. 6 offers an exemplary diagram for showing a search pattern applying a motion estimation method in accordance with a preferred embodiment of the present invention;

Fig. 7 describes a block diagram of a video encoder employed in the present invention; and

Fig. 8 sets forth a detailed block diagram of a motion estimation unit of Fig. 7 in accordance with another preferred embodiment of the present invention.

DESCRIPTION OF SPECIFIC EMBODIMENTS

Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings.

The present invention is applied to a general video sequence compression technology and may be applicable to software for operating a circuit/computer or other devices

capable of a video processing.

Figs. 1 to 3 illustrate examples of search patterns employed in the present invention.

Fig. 1 shows a case where an initial search pattern is located in a center of a search window so that an initial direction is determined.

To be specific, a block distortion measure (BDM) value is evaluated for each of five search locations, i.e., locations 0 to 4 of the initial search pattern. If a minimum BDM value is found to be at the location 0 thereof, no more search process is continued and a motion estimation process is ended. In this case, a motion vector (MV) is defined at (0,0).

Meanwhile, if a minimum BDM value occurs at either the location 1 or 3 thereof, a horizontal search pattern illustrated in Fig. 2 is used in a next stage. In case a minimum BDM value corresponds to either the location 2 or 4 thereof, a vertical search pattern illustrated in Fig. 3 is used in the next stage.

The horizontal and the vertical search patterns shown in Figs. 2 and 3 respectively have eight search locations. A motion vector is determined depending on the search locations, specifically, a location where the minimum BDM value occurs. If a minimum BDM value occurs at either a location 0 or 1 of the horizontal and the vertical search patterns, a motion vector is determined depending on the location where the minimum BDM value occurs. Then, the motion estimation process is ended.

In case a minimum BDM value is found at one of other locations of the horizontal and the vertical search patterns except the locations 0 and 1, a search pattern to be applied to a next stage is also determined depending on the location where the minimum BDM value is found.

That is to say, if either a location 2 or 5 of the horizontal and the vertical search patterns has the minimum BDM value, the horizontal search pattern shown in Fig. 2 is

again used in a next stage as shown in Fig. 4a.

To be more specific, if the minimum BDM value is found to be at the location 2 of the horizontal search pattern shown in Fig. 2, the location 2 is determined to be a location 0 of the horizontal search pattern to be used in the next stage. In case the minimum BDM value occurs at the location 5 of the horizontal search pattern shown in Fig. 2, the location 5 corresponds to the location 1 of the horizontal search pattern to be used in the next stage.

Meanwhile, in case where a minimum BDM value occurs at one of locations 3, 4, 6 or 7 of the horizontal search pattern shown in Fig. 2, a search pattern to be used in a next stage is determined to be the vertical search pattern shown in Fig. 3.

An example thereof is illustrated in Fig. 4B. In case a minimum BDM value is found at either the location 3 or 4 of the horizontal search pattern shown in Fig. 2, the location where the minimum BDM value is found is determined to be a location 0 of the vertical search pattern to be used in a next stage.

Besides, if a minimum BDM value is found to be at either the location 6 or 7 of the horizontal search pattern shown in Fig. 2, the location where the minimum BDM value is found is determined to be a location 1 of the vertical search pattern to be used in a next stage.

In case of the vertical search pattern shown in Fig. 3, if a minimum BDM value occurs at either a location 2 or 5, the vertical search pattern shown in Fig. 3 is again used in a next stage. On the other hand, if a minimum BDM value corresponds to one of locations 3, 4, 6 or 7 of the vertical search pattern shown in Fig. 3, the horizontal search pattern shown in Fig. 2 is used in a next stage.

For example, if a minimum BDM value occurs at the location 5 of the vertical search pattern shown in Fig. 3, the location 5 is determined to be the location 0 of the vertical search pattern to be used in a next stage. Further,

if a minimum BDM value is at the location 2 of the vertical search pattern shown in Fig. 3, the location 2 is determined to be the location 1 of the vertical search pattern to be used in a next stage.

In case a minimum BDM value corresponds to either the location 3 or 4 of the vertical search pattern shown in Fig. 3, the location where the minimum BDM value is found is determined to be the location 1 of the horizontal search pattern to be used in the next stage. Besides, in case a minimum BDM value occurs at either the location 6 or 7 of the vertical search pattern shown in Fig. 3, the location where the minimum BDM value is found is determined to be the location 0 of the horizontal search pattern to be used in the next stage.

Fig. 6 offers an exemplary diagram for showing a search pattern in accordance with the present invention. Especially, there illustrated a case where a minimum BDM value is found to be at a location 3 in an initial search pattern as shown in Fig. 1.

In a first stage, a BDM value is evaluated for five locations of the initial search pattern.

As a result thereof, in a second stage, a location having a minimum BDM value, i.e., the location 3, is detected

In a second stage, a horizontal search pattern as shown in Fig. 2 is used in a next stage, and the location 3 is determined to be the location 1 of the horizontal search pattern.

Meanwhile, the minimum BDM value exists at the location 4 of the horizontal search pattern, and therefore, a vertical search pattern as shown in Fig. 4B is used in a third stage.

Further, since the minimum BDM value is at the location 3 of the vertical search pattern of the third stage, a horizontal search pattern as illustrated in Fig. 5B is used in a fourth stage.

In a fifth stage, the minimum BDM value is found to be at a location 0 of the horizontal search pattern, so that the motion estimation process is ended, and finally, a final motion vector is determined to be at (3, -2).

Fig. 7 describes a block diagram of a video encoder employing the motion estimation method in accordance with the present invention, wherein the video encoder includes a block generation unit 702, a DCT conversion unit 703, a quantization unit 704, a motion estimation unit 706, a motion compensation unit 707, an inverse DCT conversion unit 708 and an inverse quantization unit 709.

The block generation unit 702 divides each frame in a video sequence into blocks of a regular size, e.g., 8×8.

Each of the blocks generated by the block generation unit 702 is provided to the motion estimation unit 706 and the motion compensation unit 707, so that the motion compensation is performed.

The DCT conversion unit 703 performs a DCT conversion on the block in which the motion compensation is carried out by the motion compensation unit 707. The quantization unit 704 quantizes the DCT converted block, to thereby output a quantized encoding stream.

Further, the inverse DCT conversion unit 708 and the inverse quantization unit 709 are utilized for using a correlation between frames in the video encoder of Fig. 7.

Various motion estimation algorithms are applied to the motion estimation unit 706. The video encoder including the motion estimation unit 706 performs motion estimation by using the method described in Figs. 1 to 5.

Fig. 8 sets forth a detailed block diagram of the motion estimation unit 706 of Fig. 7, wherein the motion estimation unit 706 includes a current frame block generation unit 801, a previous frame block generation unit 803, a first and a second memory 802 and 804, a pattern memory 805, a pattern determination unit 806 and a motion estimation unit 807. A solid line in Fig. 8 indicates a

data signal flow and a dotted line therein represents an actuating signal flow.

As illustrated in Fig. 8, the current image block generation unit 801 and the previous image block generation unit 803 generate image blocks to be used in the motion estimation unit 807 and then send the generated blocks to the first and the second memory 802 and 804.

The first and the second memory 802 and 804 respectively store the image blocks transmitted from the current image block generation unit 801 and the previous image block generation unit 803 and then send the stored image blocks to the motion estimation unit 807.

Based on data of the transmitted block, the motion estimation unit 807 performs a motion estimation process by using patterns in accordance with the present invention as described above.

In other words, the motion estimation unit 807 sends an actuating signal to the pattern determination unit 806 and the pattern determination unit 806 provides the actuating signal to the pattern memory 805. Thus, the pattern memory 805 receives search patterns described in Figs. 1 to 3.

The search patterns transmitted to the pattern memory unit 805 are provided to the motion estimation unit 807 again to thereby be used for a search process.

Depending on a result of the search process performed by using the transmitted search patterns, the motion estimation unit 807 sends search patterns to be used in a next stage to the pattern determination unit 806 and the pattern memory unit 805 through the actuating signal, so that the above-described processes are repeated.

If the minimum BDM value is found to be at the location 0 or 1 of Figs. 2 and 3 thereby ending the motion estimation process, a motion vector MV depending on the above-mentioned search locations is outputted.

The present invention is able to provide a

computationally efficient motion estimation method and avoid a convergence to a location minimum value that may occur during the search process.

While the invention has been shown and described with respect to the preferred embodiments, it will be understood by those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the invention as defined in the following claims.

CLAIMS

1. A method for motion estimation using adaptive patterns in a video sequence compression system, comprising the steps of:

(a) determining an initial search pattern located at a center of a search window in a block of a video frame;

(b) searching a location of a minimum block distortion measure (BDM) in the initial search pattern;

(c) determining a horizontal search pattern for functioning on the search window in the horizontal direction to search a location of a minimum BDM in the horizontal search pattern;

(d) determining a vertical search pattern for operating on the search window in the vertical direction to search a location of a minimum BDM in the vertical search pattern;

(e) designating the location of the minimum BDM in the initial search pattern to be a motion vector;

(f) designating the location of the minimum BDM in the horizontal search pattern to be a motion vector;

(g) designating the location of the minimum BDM in the vertical search pattern to be a motion vector;

(h) determining a search pattern to be used in a subsequent searching stage based on the location of the minimum BDM in the initial search pattern;

(i) determining a search pattern to be used in a subsequent searching stage based on the location of the minimum BDM in the horizontal search pattern; and

(j) determining a search pattern to be used in a subsequent searching stage based on the location of the minimum BDM in the vertical search pattern.

2. The method of claim 1, wherein ones of the locations on the initial search pattern, the horizontal search pattern and the vertical search pattern are overlapped and the

overlapped search location is excluded in determining a BDM.

3. The method of claim 2, wherein the initial search pattern includes 4n+1 search locations which is formed of a single one at the center of the initial search pattern and 2n in each of the vertical and the horizontal direction from the center thereof, the horizontal search pattern for functioning in the horizontal direction includes hexagonal 8n search locations which is formed of 2n in a top row, 4n in a middle row and 2n in a bottom low, and the vertical search pattern for operating in the vertical direction includes hexagonal 8n search locations which is formed of 2n in a left side column, 4n in a middle column and 2n in a right side column, n being a positive integer.

4. The method of claim 3, wherein the step (h) includes the steps of:

(h1) determining the vertical search pattern to be a search pattern to be used in a subsequent searching stage in case a minimum BDM occurs at one of the 2n search locations in each of the top and the bottom row;

(h2) determining the horizontal search pattern to be a search pattern to be used in a subsequent searching stage in case a minimum BDM is found at one of the 2n search locations in each of the left and the right side column; and

(h3) ending a search process in case a minimum BDM corresponds to the center.

5. The method of claim 4, wherein the step (i) includes the steps of:

(i1) ending a search process in case a minimum BDM occurs at one of 2n search locations in a center of the middle row;

(i2) selecting the horizontal search pattern for a subsequent searching stage in case a minimum BDM is found at one of the search locations of both sides except the 2n

search locations in the center of the middle row; and

(i3) selecting the vertical search pattern for a subsequent searching stage in case a minimum BDM is at one of the search locations in the top and the bottom row.

6. The method of claim 5, wherein the step (j) includes the steps of:

(j1) ending a search process in case a minimum BDM occurs at one of 2n search locations in a center of the middle column;

(j2) selecting the vertical search pattern for a subsequent searching stage in case a minimum BDM is found at one of vertical search locations except the 2n search locations in the center of the middle column; and

(j3) selecting the horizontal search pattern for a subsequent searching stage in case a minimum BDM is at one of the search locations in the 4n number of search locations in the left and the right column.

7. An apparatus for motion estimation using adaptive search patterns for a video sequence compression, comprising;

a current image block generation means for generating a current image block;

a previous image block generation means for generating a previous image block;

a first and a second memory for storing the image blocks generated by the current image block generation means and the previous image block generation means; and

a pattern determination and motion estimation means for retrieving data of image block stored in the first and the second memory to search a location of a minimum BDM in a current search pattern of the data of the retrieved image block and determining a next search pattern to be used in a subsequent searching stage depending on the location of the minimum BDM.

8. The apparatus of claim 7, wherein the pattern determination and motion estimation means repeatedly estimates a new search pattern to be used in a subsequent searching stage based on a result of a search process performed by using the next search patterns.

FIG. 1

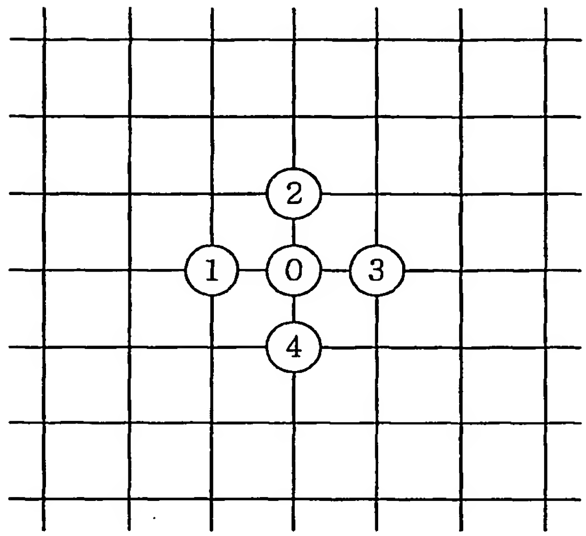


FIG. 2

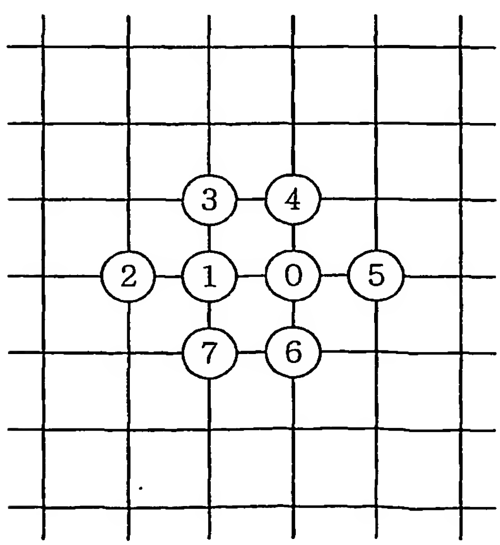
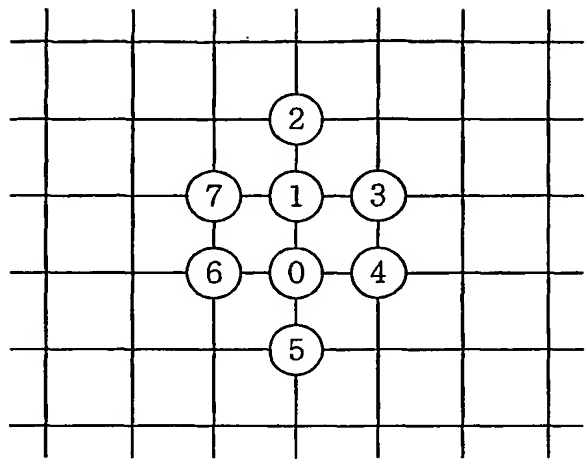


FIG.3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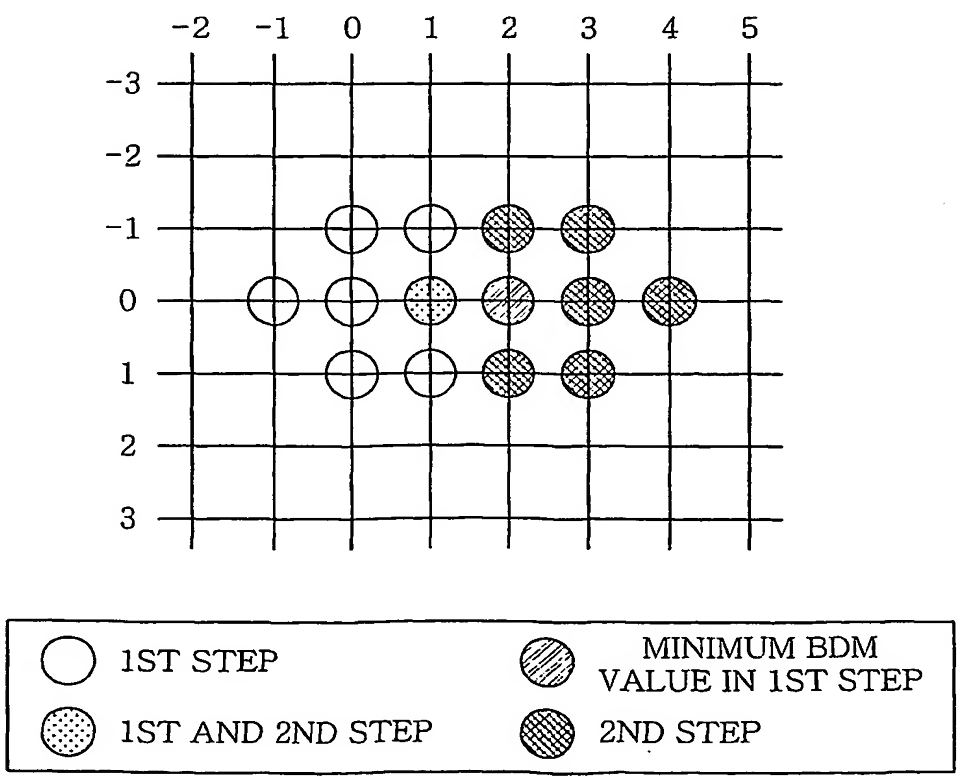
3
6
0
4
5

FIG.4A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5
-3
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-1
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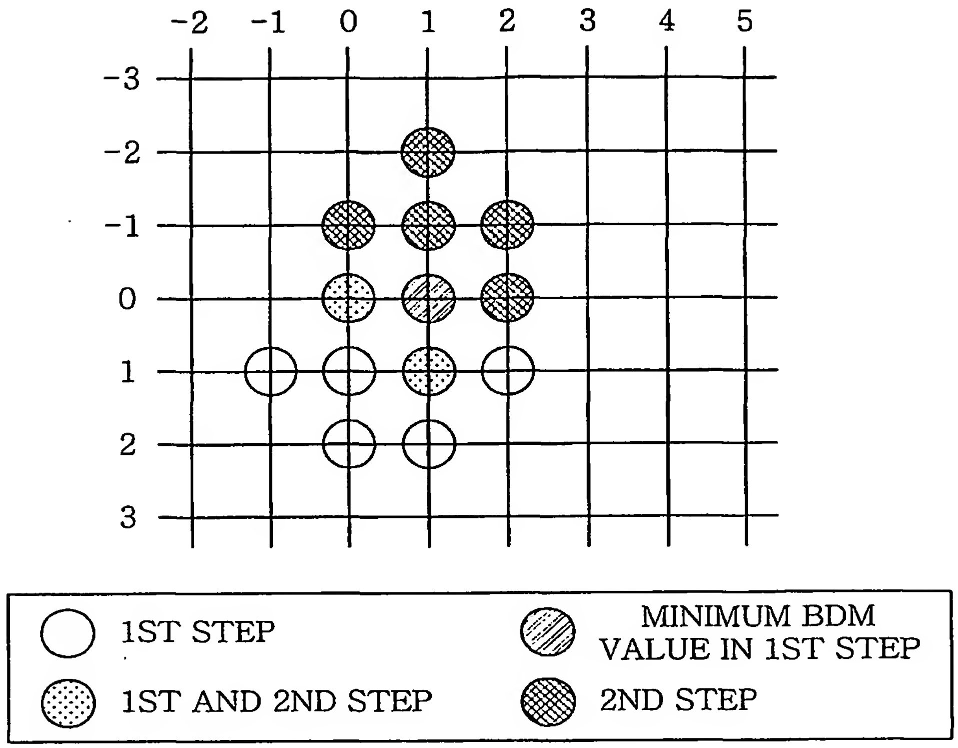
1ST STEP
MINIMUM BDM VALUE IN 1ST STEP
1ST AND 2ND STEP
2ND STEP

FIG.4B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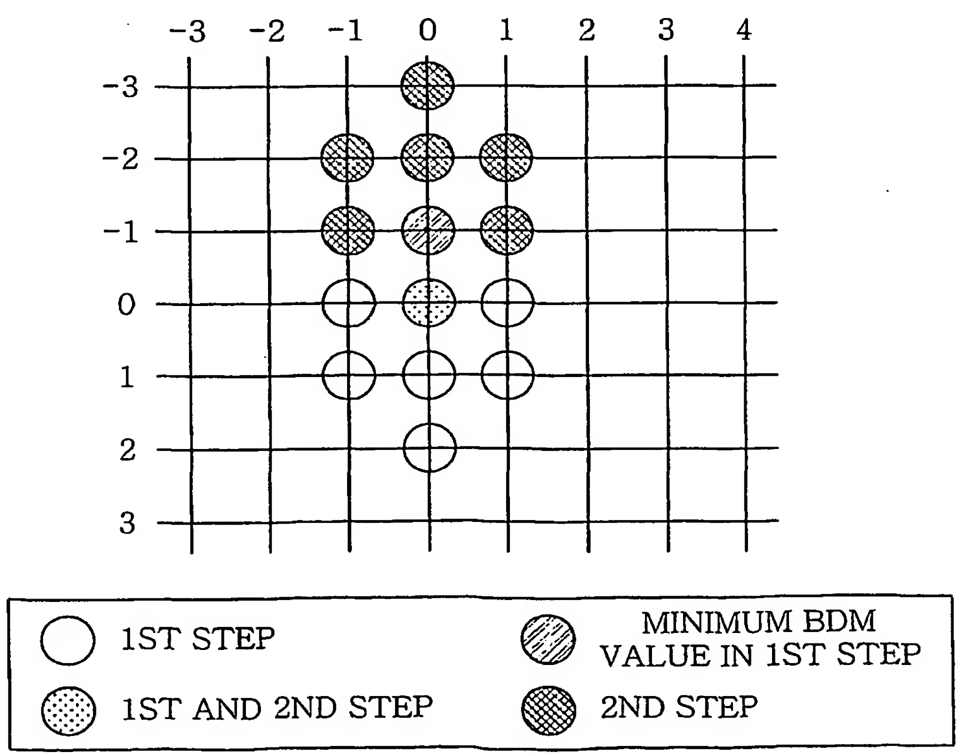
-3 -2 -1 0 1 2 3
1ST STEP
MINIMUM BDM VALUE IN 1ST STEP
1ST AND 2ND STEP
2ND STEP

FIG.5A


-3 -2 -1 0 1 2 3 4
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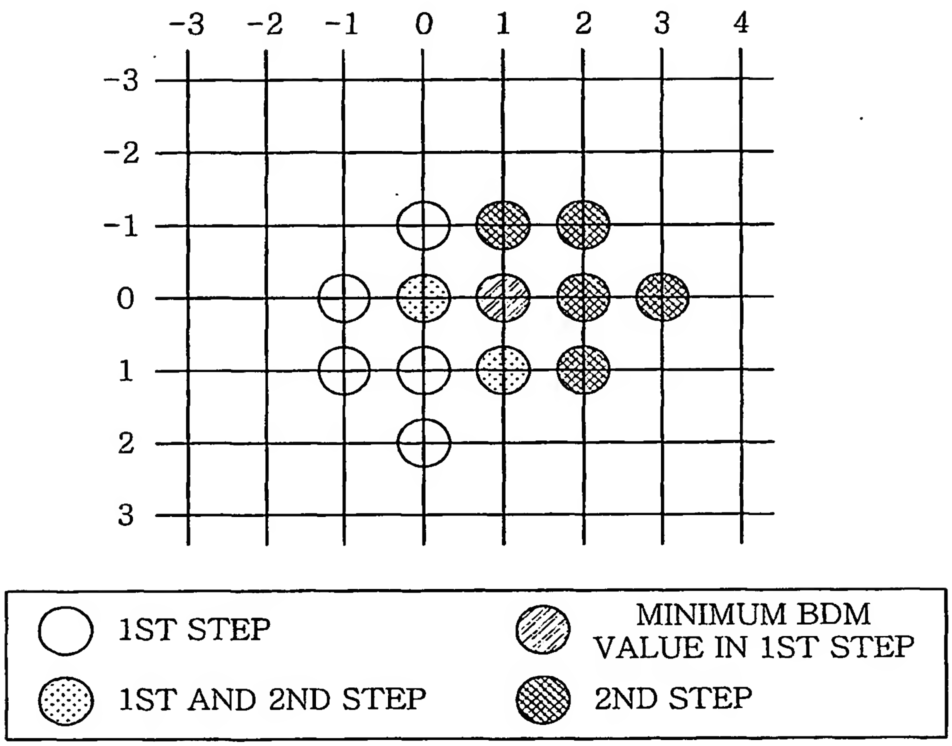
1ST STEP
MINIMUM BDM VALUE IN 1ST STEP
1ST AND 2ND STEP
2ND STEP

FIG.5B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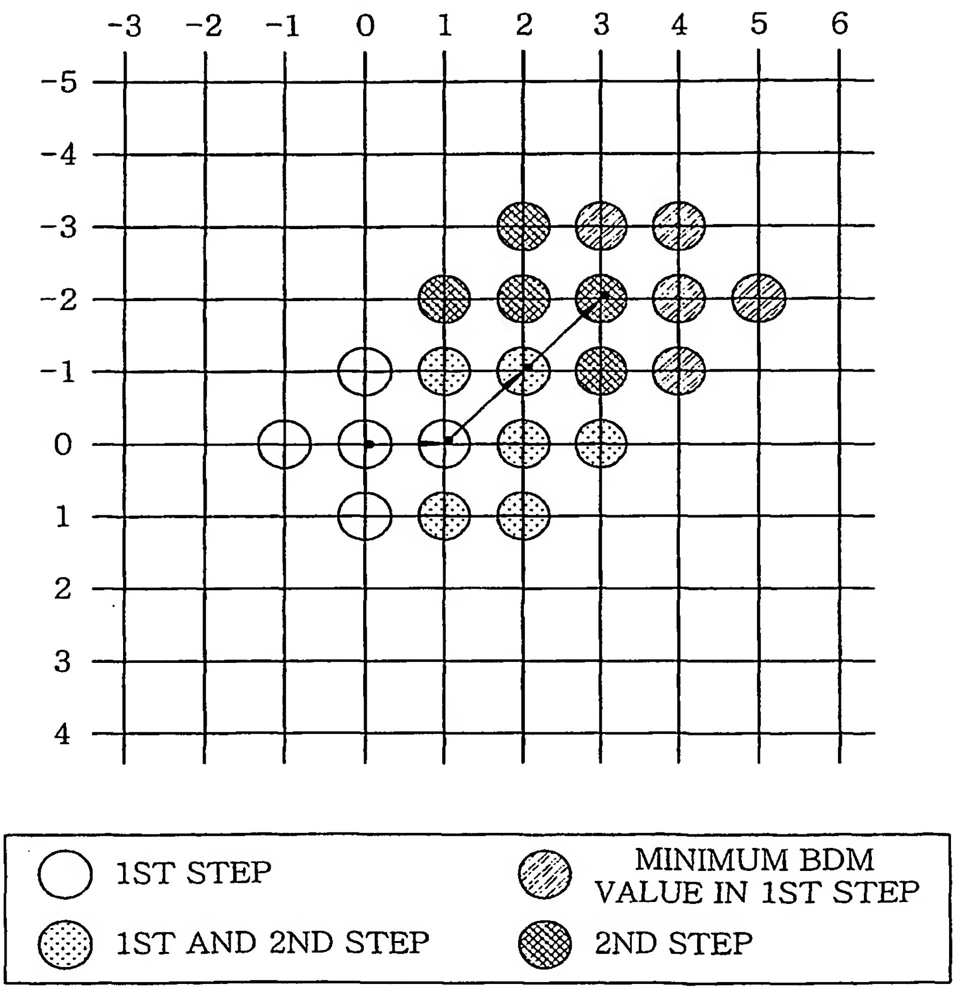
1ST STEP
MINIMUM BDM VALUE IN 1ST STEP
1ST AND 2ND STEP
2ND STEP

FIG.6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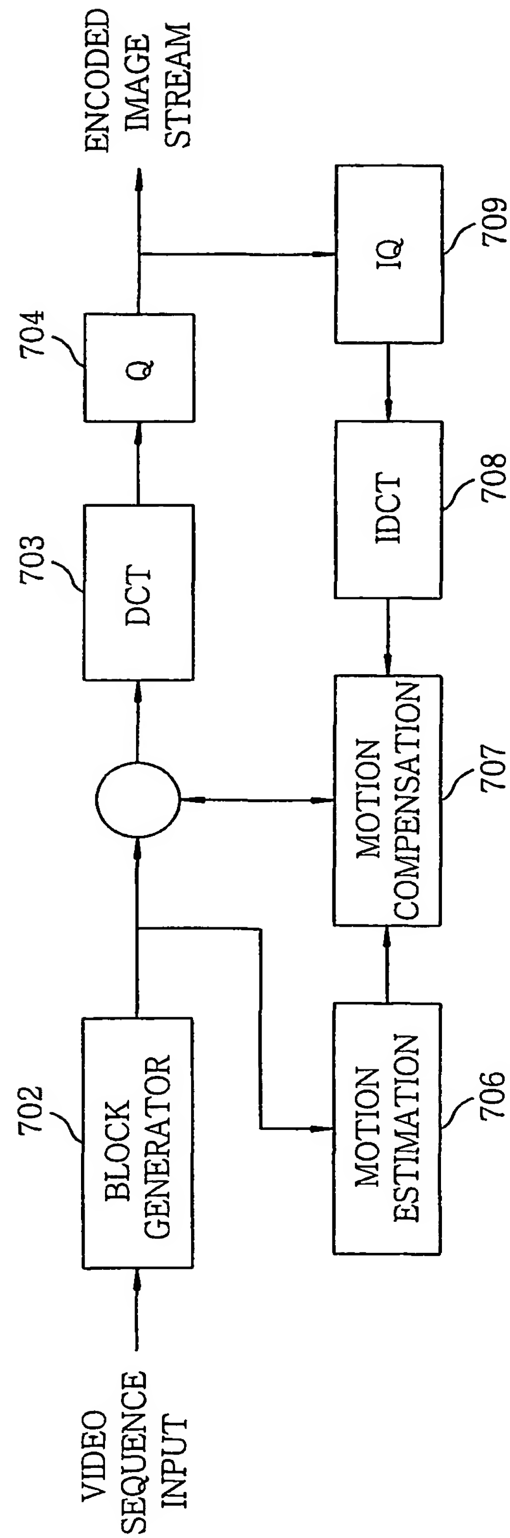
1ST STEP
1ST AND 2ND STEP
MINIMUM BDM VALUE IN 1ST STEP
2ND STEP

FIG.7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BLOCK GENERATOR
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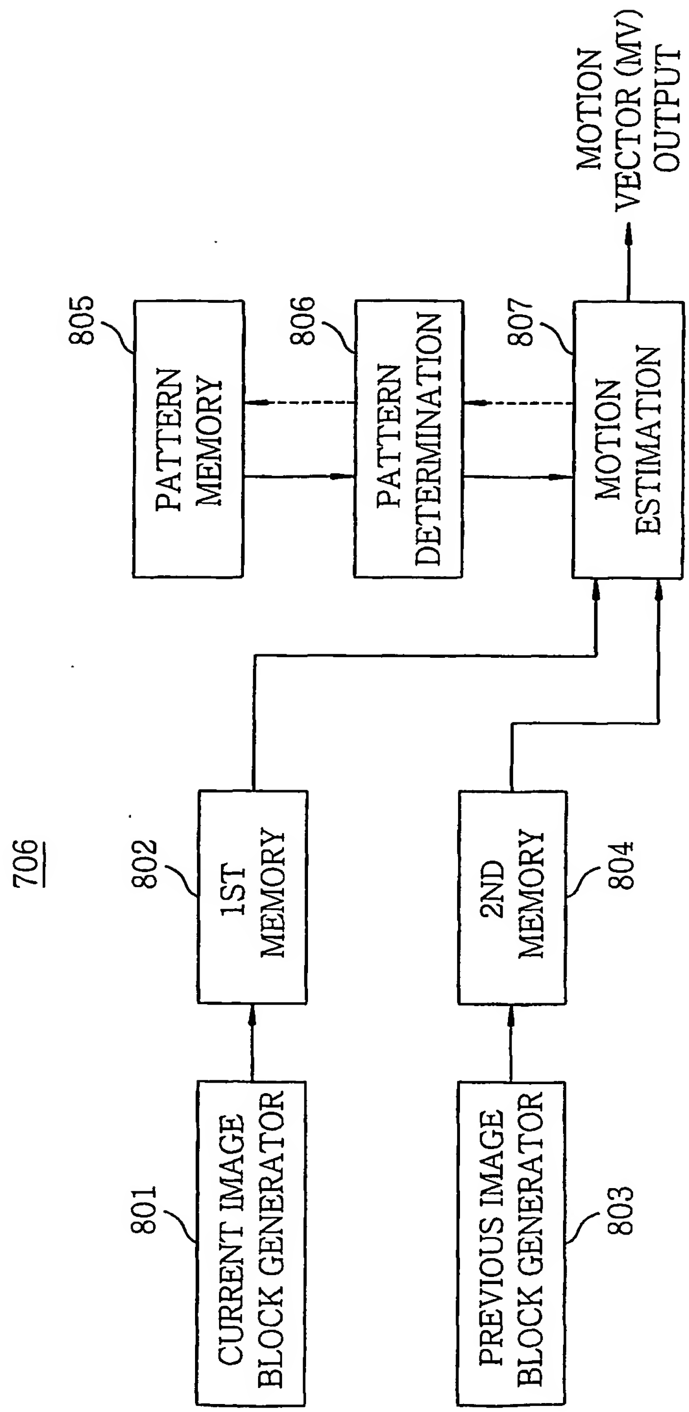
DCT
704
Q
ENCODED IMAGE STREAM
706
MOTION ESTIMATION
707
MOTION COMPENSATION
708
IDCT
709
IQ

FIG.8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1ST MEMORY
803
PREVIOUS IMAGE BLOCK GENERATOR
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807
MOTION ESTIMATION
MOTION VECTOR (MV) OUTPUT